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A punctuated model for the colonisation of the Late Glacial margins of northern Europe by Hamburgian hunter-gatherers

Ein diskontinuierliches Modell für die Besiedlung der spätglazialen Marginalräume Nordeuropas durch Jäger und Sammler der Hamburger Kultur

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Abstract - The earliest Upper Palaeolithic movements into northern Europe appear at the very end of the Last Ice Age. Traditionally, the colonisation of this area is seen as a rather continuous process that, once started, persists without major interruptions. However, many lines of evidence are rather consistent with a significantly different understanding of this colonisation as a series of events with much more punctuated colonisation pulses and times in between where these areas were devoid of human presence. We here discuss the archaeological implications of such colonisation-decolonisation pulses with a focus on the Late Glacial Hamburgian culture. The archaeological record of the Hamburgian is discussed in relation to how pioneering forager communities are expected to behave in order to then evaluate to what extent the archaeological record matches the expectations. Archaeological evidence in the form of lithic projectile points and radiocarbon data is presented in tentative support of the punctuated nature of Hamburgian presence. Together, these lines of evidence strengthen the notion that the Hamburgian settlement of Northern Europe appeared in two distinct and brief episodes. The later of these episodes is connected with the distinct Havelte projectile points, which we interpret as the archaeological signatures of individual flintknappers who were temporally and socially closely related and who were present in southern Scandinavia over a period of only a few years. The model we present here is significantly different from the traditional interpretations of the Hamburgian but is, we argue, consistent with the current evidence.

***Zusammenfassung -** Die früheste jungpaläolithische Besiedlung Nordeuropas erfolgte am Ende der letzten Eiszeit. Die Kolonisierung dieses Gebiets wird traditionell als ein eher kontinuierlicher Prozess angesehen, der, einmal begonnen, ohne größere Unterbrechungen andauerte. Es gibt jedoch einige Hinweise, die mit einer deutlich anderen Lesart der Kolonialisierung besser in Einklang zu bringen sind und den Prozess als eine Folge stark diskontinuierlicher Besiedlungsereignisse ausweisen, zwischen denen die Gebiete menschenleer waren.*

Wir diskutieren hier die archäologischen Implikationen solcher Kolonisierungs-Dekolonisierungs-Pulse mit einem Fokus auf der spätglazialen Hamburger Kultur. Der archäologische Befund der Hamburger Kultur wird hierbei ins Verhältnis zu einem Erwartungshorizont gesetzt, der das Verhalten von Jäger-Sammlern beschreibt, die in neue Gebiete vordringen, um zu beurteilen, inwieweit Befund und Erwartungen übereinstimmen. Die diskutierten archäologischen Hinweise, namentlich lithische Projektile und Radiokarbondaten, sprechen eher für die diskontinuierliche Anwesenheit von Jäger-Sammlern der Hamburger Kultur. Gemeinsam bestärken diese beiden Befundgruppen den Eindruck, dass die Besiedlung Nordeuropas durch die Hamburger Kultur als zwei von einander getrennte und eher kurze Episoden erfolgte. Die jüngere dieser Episoden ist mit den charakteristischen Havelte-Spitzen verbunden, die wir als archäologische Signatur einzelner Individuen interpretieren, die zeitlich und sozial eng verbunden waren und sich in Südskandinavien nur für wenige Jahre aufgehalten haben. Das hier vorgestellte Modell unterscheidet sich somit deutlich von den traditionellen Interpretationen der Hamburger Kultur, ist unserer Meinung nach aber konsistent mit den aktuellen archäologischen Befunden.

Keywords - **Late Palaeolithic, Hamburgian culture, radiocarbon dates, southern Scandinavia, pioneer occupation, individuals**
Spätpaläolithikum, Hamburger Kultur, Radiokarbondaten, Südskandinavien, pionier Siedlung, Individuen

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Introduction

Since the seminal paper by Ammerman and Cavalli-Sforza (1971), the spread of populations is often modelled as a wave of advance, where population growth leads to an expansion of the settlement area and eventually results in migration into new (already populated or unpopulated) areas. While this model of colonisation processes may work well for sedentary societies, pioneering hunter-gatherer colonisations most likely proceeded differently. In mobile, small-scale societies, so-called leapfrog models suggest a rather more disjunct pattern of small groups moving in and out of certain areas, depending on specific circumstances at a given place and time (e.g. Housley et al. 1997; Hazelwood & Steele 2003). For forager communities in higher latitudes and especially in arctic environs, stark environmental variability and hence economic uncertainty was and remains a reality, with significant implications for mobility, social relations and, not least, demography (Smith 1978). McGhee (2009: 82–83) reflects on this demographic variability, especially with regard to pioneer colonisers in the North:

Arctic populations have potentials for extremely rapid growth rates when circumstances allow, but… long-term growth rates are reduced by sporadic starvation episodes occasioned by unpredictable environmental factors, bad luck or bad planning… [T]his would have been especially true during the early decade of movement into previously unknown territory. Thule people were expanding into a resource-rich area, but one that required the acquisition and accumulation of considerable local knowledge in order to exploit productively…The concept of carrying capacity means little in a region that will support 1000 people in nine years out of ten, but on the tenth year it will support no-one. The population size of arctic communities is controlled more by chance than by carrying capacity.

Transferring ethnographic insights directly to the archaeological record of the Palaearctic such as the Late Glacial of Northern Europe (e.g. Troels-Smith 1956) should only be done with due caution. Yet, reflecting comparatively and quantitatively across a wide range of ethnographic groups, their environmental conditions and population densities, Kretschmer (2015) has suggested that densities ≤0.002 persons/km^2 make foragers susceptible to extinction. This susceptibility is likely, following Wobst's (1976) seminal work on locational relations in Palaeolithic foragers, to have been further pronounced in those populations operating at the periphery of past social networks. Interestingly, Kretschmer's reconstructed population densities for the Late Glacial Hamburgian culture (14'700-14'000 calBP) of Northern Europe, using the Cologne protocol for palaeodemographic estimates (cf. Schlummer et al. 2014; Kretschmer 2012) are 0.003-0.001 persons/km^2, i.e. *at or below the suggested extinction susceptibility threshold at least some of the time.* This is further supported by considerations of animal biomass and diversity – as well as the specific behavioural and demographic characteristics of the keystone species reindeer – in this period that also suggest population densities that would or could trend towards zero (Riede 2014a).

In this paper, we explore the archaeological implications of such potential population instability and the attendant sporadic absences of, in particular, pioneering human populations with specific reference to the Hamburgian culture of Northern Europe. In doing so, we take a perspective from the northern margins of the currently known distribution of this technocomplex. In the following, we offer a brief review of the Hamburgian culture in southern Scandinavia, explicitly Denmark and northern Germany, and how this period is traditionally understood. We juxtapose this evidence with general expectations of pioneering foragers in order to assess to what degree the Hamburgian conforms to these expectations. We then focus in on presenting (i) new lithic evidence from two recently excavated Hamburgian sites of the Havelte phase – Krogsbølle in eastern Denmark and Jels 3 in western Denmark – that serves as an initial platform for reflecting on the potential true patchiness of human presence in the early part of the Late Glacial in the region; (ii) a literature-based comparison with 'classic' Hamburgian assemblages; and (iii) a novel processing of the currently available numerical dates for the Hamburgian. These lines of evidence support the notion that the Hamburgian occupation in Northern Europe took the form of two distinct and brief episodes. The younger episode is associated with the Havelte projectile point variants, which we here interpret as the archaeological signatures of only very few people who were present in southern Scandinavia over a few years at best. This model diverges considerably from traditional views of the Hamburgian but is, we argue, consistent with the evidence currently at hand. We close by providing ways of testing our model.

The Hamburgian culture in brief

Since its inception, Palaeolithic research has had a strong focus on long-term cultural processes. As a result, single archaeological type sites have traditionally become interpreted as representing culture-historical epochs (e.g. Otte & Keeley 1990). Such an interpretative framework has been applied to a large extent by researchers when dealing with hunter-gatherer dispersal dynamics in southern Scandinavia during the Late Glacial (~18'000-11'700 calBP) (cf. Andersen 1988; Madsen 1996). This has resulted in an understanding of human presence in the area as having begun with a successful pioneer colonisation, followed by a strong cultural continuity across and between several different cultural traditions and an unbroken use of the landscape. However, there is increasing evidence, which points away from this interpretation and towards an understanding of Late Palaeolithic human settlement as a more punctuated phenomenon.

The focus of this particular paper therefore rests on the earliest known human presence in southern Scandinavia, the Late Palaeolithic (~14'500-14'000 calBP) Hamburgian culture, first described by Alfred Rust (1937) on the basis of excavations near Hamburg in northern Germany and recognised in Denmark in the 1980's (Holm & Rieck 1983, 1987, 1992). Although efforts to provide very detailed phases for the Hamburgian have been made (Tromnau 1975), the Hamburgian is now commonly divided into two phases (cf. Clausen 1998), where the 'classic' Hamburgian, known from Poland, Germany and the Netherlands marks the earliest phase, and the Havelte phase, known from north-western Europe, representing the later part of the Hamburgian timespan.

Detailed analyses of the Hamburgian technological tradition have convincingly demonstrated evident similarities to the Central European Magdalenian. At the same time, the typological composition of Hamburgian assemblages is sufficiently distinctive from Magdalenian ones to discriminate them in multivariate statistics (Maier 2015: 133). Fully in line with earlier suggestions, the Hamburgian is hence understood to have originated from that cultural substrate and as having had a dispersal trajectory mainly from the south-west (Weber 2012; Riede 2014b). However, evidence also points towards the Late Glacial Elbe-Vistula system as a main route into the north (Burdukiewicz 1987). Moreover, a movement from different parts of the northern margins of the upland zone onto the plain, has equally been proposed (Otte et al. 1984). The Hamburgian colonisation of southern Scandinavia is connected with the Havelte Group. On a broad scale, Hamburgian settlement activities took place between Greenland Interstadials GI-1e and GI-1c$_3$, in other words, the warm phases of the Bølling and the early Allerød (Grimm & Weber 2008). Due to many older radiocarbon dates available for the Hamburgian and a particularly problematic part of the calibration curve, however, the chronology for the Hamburgian has remained poorly resolved.

One consequence of this chronological imprecision is the conceptualisation of the Hamburgian in the textbook culture-historical sequence in the region. The Hamburgian presence in southern Scandinavia is generally interpreted as a long-lasting process with considerable human presence, despite that fact that such evidence is sparse. Furthermore, the transition from the earlier 'classic' Hamburgian to the Havelte phase and then contiguously to the Federmessergruppen (Andersen 1988; Larsson 1996), Brommean (Madsen 1996) or Ahrensburgian (Bordes 1968) has most commonly been framed as a gradual transition reflecting adaptations to changing environments (Fig. 1). This rests in the traditional understanding of

Years BP	Epochs	Phases	Archaeological Cultures
11000	Holocene	Preboreal	Ahrensburgian
12000	Pleistocene	Younger Dryas	
13000		Allerød	Bromme
14000			Federmessergruppen
15000		Older Dryas	Hamburgian
16000		Bølling	

Fig. 1. A typical figure showing the natural- and cultural development through Late Glacial Denmark. In this figure, the Hamburgian culture abuts the subsequent Federmessergruppen and is represented as one homogenous block of human presence; transitions and possible hiatuses are invisible in such schemes. Redrawn and modified from Price (2015).

Abb. 1. *Eine typische Abbildung der natürlichen und kulturellen Entwicklung im spätglazialen Dänemark. In dieser Abbildung grenzt die Hamburger Kultur an die darauffolgenden Federmessergruppen und ist als homogener Block menschlicher Anwesenheit dargestellt. Übergänge und mögliche Hiaten sind unsichtbar in solchen Schemata. Neu gezeichnet und verändert nach Price (2015).*

the relationship between these Late Glacial cultural elements, but it is also a reflection of the fact that research, focused specifically on the Hamburgian culture has been very limited until quite recently (cf. Weber 2012). Some of these earlier suggestions linking the Hamburgian to the Bromme culture or even the Ahrensburgian are now obsolete given the large dating gap highlighted by the radiocarbon dates that have become available since (Riede & Edinborough 2012). Indeed, divergent opinions with regard to the underlying nature of forager settlement and the process of colonisation can also be found. Closely aligned with our argument, Eriksen (1999: 167), for instance, describes the Hamburgian settlement as "likely to have been both episodic and ephemeral". Similarly, Brinch Petersen (2009) and Riede (2009b, 2014a) also favour discontinuous models, given, in particular, the rather glaring differences in the lithic repertoires of the Hamburgian and all subsequent Late Glacial cultures. In an effort to better understand just how episodic and ephemeral the Hamburgian presence at its northern margins were, we place this techno-complex in the context of other Palaeolithic colonising groups and focus further in on two aspects in particular: projectile point shape variation and radiocarbon dates.

Comparing the Hamburgian to model colonisers

One approach for understanding the Hamburgian and for reflecting on its demographic and cultural relationship with subsequent techno-complexes is to compare it with a synthetic model for pioneering foragers (Fig. 2). By bringing together useful discussions of the behavioural and ecological signatures – and the demographic corollaries of these (MacDonald 1998; Surovell 2000) – of pioneering

Signature categories			Model pioneers	Hamburgian
Technology	I	Toolkit design	A: Portable, high quality raw material, long use-life; B: Relatively simple with few tool types	A
	II	Storage	Range mobility substitutes for storage	1
Economy	III	Resource focus	Animal focus; smaller assemblages; periodic shortages mitigated through range relocation	1
	IV	Movement strategy	High residential and logistic mobility; high range mobility	1
Mobility	V	Settlement hierarchy	Short-term redundant use of 'known places'	1
	VI	Regionality	Low	1
Landscape	VII	Landscape knowledge	Limited local knowledge	1
Chronology	VIII	Stratigraphic position	Underlying or pre-dating 'developed' phase assemblages in site or region	0

Fig. 2. A summary of Hazelwood & Steele's (2003) eight behavioural and technological traits characteristic of pioneer hunter-gatherers in relation to the trends observable in the Hamburgian. The very last column describes presence (1) or absence (0) of these specific traits. As is shown, the Hamburgian conforms nicely with these pioneer characteristics. It is here important to stress that not all points in a model have to be met, in order to be significant.

***Abb. 2.** Zusammenfassung der acht Verhaltens- und Technologie-Eigenschaften, die für Jäger-Sammler, die in unbekanntes Gebiet vordringen, charakteristisch sind (Hazelwood & Steele (2003), im Vergleich zum Trend, der für die Hamburger Kultur beobachtbar ist.*

Palaeolithic foragers by Kelly (2003) and Davies (2001), it becomes evident that foragers often employ very similar strategies when entering novel territories, and leave very similar *archaeological* signatures. We discuss these signatures in turn below.

Toolkit design

The Hamburgian lithic technology itself is very characteristic with diagnostic tools such as the typical Zinken, burins and end-scrapers, often with lateral retouch, practically all made from blades produced from opposed-platform blade cores (e.g. Hartz 1987; Weber 2012). Hamburgian lithic technology and reduction strategies are seen as rather normative and efficient, producing standardised, light-weight tool components. Noteworthy is the high frequency of combination tools, which can be interpreted as a way of further conserving weight in the total toolkit by combining the function of two tools into one blade component – albeit with the concomitant risk of losing two tools upon a single breakage event.

The foremost diagnostics of the Hamburgian are the projectile points, which are likely to have been used as part of a bow and arrow technology (Riede 2010; Weber 2009). These consist of the asymmetrical 'classic' shouldered points indicating the earlier Hamburgian and the somewhat more symmetrical and more carefully worked points indicating the slightly later Havelte group (Fig. 3).

During excavations of the Havelte phase locality of Krogsbølle on the Danish island of Lolland – known previously from surface finds and test-pitting (Westen 2006, 2007) but excavated for the first time in 2012 (Riede et al. in press) – , it was observed that the projectile points in this inventory fall into two distinct variants, which seems to be worked and shaped quite differently, but in a deliberate fashion, especially with regard to the form of the tang. Variant A represents a relatively short projectile point with an alternatingly retouched tang, which tapers towards the base. In contrast, variant B represents a long projectile point, which retains a broad tang with a more or less angular base and what could be called a notch. Each variant is represented by two examples, which are similar in blank selection, final size, application of retouch and fracture patterning (Riede et al. in press; Fig. 4). Nearly identical parallels of these two variants, and only these two, can be identified across different sites in all southern Scandinavian Havelte inventories (Riede & Pedersen 2018). Whether one of these two variants is occurring more frequently than the other is yet to be

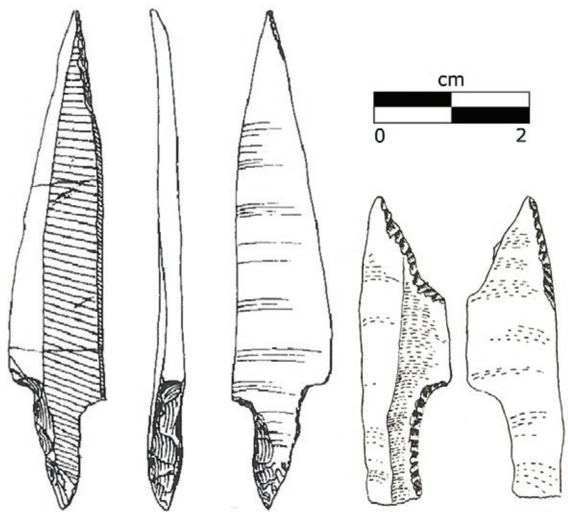

Fig. 3. Examples of the diagnostic Havelte tanged points (left, from Holm & Rieck, 1992) and the 'classic' shouldered projectile points (right, from Rust, 1937).

***Abb. 3.** Beispiele von diagnostischen Havelte Stielspitzen (links, aus Holm & Rieck, 1992) und "klassischen" Kerbspitzen (rechts, aus Rust, 1937).*

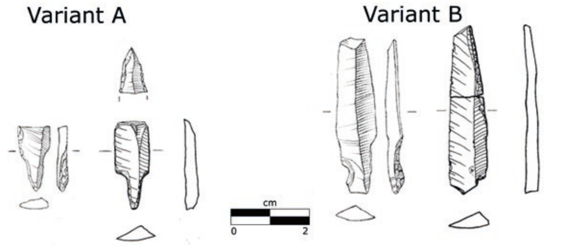

Fig. 4. Projectile points discovered at the Havelte locale 'Krogsbølle' on the island of Lolland in eastern Denmark. These clearly make out two distinct variants. Drawings by Louise Hilmar, Moesgård Museum.

Abb. 4. *Projektilspitzen von der Havelte-Fundstelle "Krogsbølle" auf der Insel Lolland in Ostdänemark. Es zeigen sich zwei unterschiedliche Varianten. Zeichnungen von Louise Hilmar, Moesgård Museum.*

determined. Furthermore, recent analysis of the hitherto unpublished Hamburgian site of Jels 3 in south-western Denmark, have revealed projectile point fragments that are highly similar to those at other south Scandinavian sites (Fig. 5).

In contrast, a much larger diversity is observed among projectile points of the classic Hamburgian despite the highly standardised character of other aspects of the lithic inventory (Weber 2008; Grimm et al. 2012). Individual flintknappers can, on occasion, be identified through their products (e.g. Whittaker 1987; Bodu et al. 1990; Dobres 2000); in line with numerous recent studies that stress the role of individual craftspeople in the past (Gamble & Porr 2005; Nørgaard 2015), it has been suggested that these distinct variants observed within Havelte assemblages may in fact represent either the work of only a few individual flintknappers, active at all these sites, or micro-traditions practiced by individuals, which were *culturally* and *temporally* closely related (cf. Tehrani & Riede 2008). Interestingly, the occurrence of the so-called *en éperon* core platform preparation technique is also commonly seen as a Hamburgian

Fig. 5. Projectile points discovered at a newly excavated Havelte locale (Jels 3) at the Jels lakes in southern Denmark. These are clear parallels to the Krogsbølle points. Drawings by Louise Hilmar, Moesgård Museum.

Abb. 5. *Projektilspitzen einer kürzlich ausgegrabenen Havelte-Fundstelle (Jels 3) an der Jels Seengruppe in Süddänemark. Es zeigen sich deutliche Parallelen zu den Spitzen aus Krogsbølle. Zeichnungen von Louise Hilmar, Moesgård Museum.*

trait. It does, however, only occur occasionally and in selected assemblages (Barton 1991; Weber 2008, 2012). Like the projectile point variants, this technique may also reflect not so much a manufacturing standard shared widely within this Late Palaeolithic community of practice (cf. Lave & Wenger 1991) but rather the preference of few individuals. This argument finds further support in how strongly the presence and absence of en éperon preparation varies in Magdalenian assemblages (Maier 2015: tables of technological recordings). It seems that applying this method of technical security is not an integral or common part of the Late Palaeolithic technological recipe, but rather reflects individual preference.

Storage

Storage of food and raw materials is, alongside social networks, economic intensification and diversification and mobility, one of the key ways in which traditional societies mitigate food crises (Halstead & O'Shea 1989). From the Hamburgian, only one potential but unlikely (Riede 2009b) flint cache is known, from Teltwisch 1 (Tromnau 1984). Earlier notions of underwater meat storage in the Ahrensburg Tunnel-valley are also no longer considered likely (Bratlund 1994, 1996; Grønnow 1985). In sum, there is no evidence for stored food in the Hamburgian, a picture that almost certainly is marred by preservation bias to some degree. It is equally likely, however, that storage was not practiced at a substantial scale and that instead – as suggested by the pioneering model – range mobility was increased in times of crisis.

Resource focus

Using the placing of the Hamburgian sites in the landscape as well as the archaeological evidence of faunal remains, the Hamburgian culture is interpreted as a hunter-gatherer culture relying heavily on reindeer. This economy was supplemented with horse (Bratlund 1994) and likely with small game, fish and available plant resources as well (Kabacinski & Sobkowiak-Tabaka 2009) albeit it is reasonable to infer that the primary subsistence resource consisted of reindeer – not least because other large mammals had not yet migrated to southern Scandinavia (Riede et al. 2010).

As already alluded to in the introduction, reindeer constitute a remarkable animal resource, but also one that is notoriously unstable, despite stable characteristics, such as main migration directions between seasonal grazing areas. In spite of the hunters' ability to adapt their hunting methods, case studies of specialised reindeer hunters suffering severe demographic caesura due to fluctuations in reindeer herd movement and size can readily be found in the ethnographic and ethno-historic literature (Minc 1986; Minc & Smith 1989; Stenton 1991). The combined paucity of mammalian biodiversity and the instability of reindeer populations are likely to have had implications for both Hamburgian mobility and demography. The faunal assemblages of the northern part of the Magdalenian (Rhineland, eastern Germany, Poland) are dominated by horse (Maier 2015: table A.7). This indicates that experiences hunting reindeer existed, but rather as a supplementary game and that the adaption to such a subsistence economy may have been challenging. First, Morin (2008) has shown that forager population densities correlate significantly with large mammal diversity. Seen in this light, the very low diversity of mammals in the early part of the Late Glacial in southern Scandinavia (Aaris-Sørensen 2009) would imply correspondingly low population densities – in fact, population densities that also trend towards 0 (Riede 2009a).

In addition, the pioneer forager model suggests that, again, resource shortages are mitigated through increased mobility. In the case of the Hamburgian, this implies relocation according to the migration of reindeer herds leading to both seasonal occupation and substantial mobility. Whether it was at all possible for foragers to follow reindeer herds on foot has been discussed widely in the literature where the general consensus is that such a strategy would have been difficult to effectuate without long-term negative demographic consequences (Sturdy 1972, 1975; Gordon 1990; Gordon et al. 1990; Burch Jr & Blehr 1991). The Havelte phase site at Howburn Farm in Scotland (Ballin et al. 2010, 2018) could be seen to reflect such increased range mobility – regardless of the demographic consequences – well beyond the traditionally recognised area used by Hamburgian foragers. Its complete isolation furthermore indicates, fully in line with the arguments stated here, that settlement pulses to the north were short and ephemeral.

One factor, which concerns the settlement picture during the Late Glacial, is the now submerged landscape of Doggerland. It is often argued - and certainly also possible - that this particular area has been occupied by hunter-gatherers during the Late Glacial. However, recent studies show a lack in the archaeological record of this area during the period in question (Peeters & Momber 2014; Momber & Peeters 2017). Although the taphonomic distortions acting on any material from this now submerged area would be and still are considerable, tabulations of the many finds derived from recent research focussed precisely on this matter show that the number of Late Glacial objects is quite limited compared to finds from both previous and following periods. It is thus unclear whether a larger population in this area can be assumed.

Movement strategy

A discussion of Hamburgian mobility and movement strategies relates closely to, on the one hand, aspects of economy and, on the other, expressions of regionality. As argued here, the strong focus on reindeer as a key resource necessitated high mobility. The lightweight Hamburgian toolkit, including the weight-saving strategy of employing an increased number of combination tools, can also be seen to reflect transport concerns.

Moving towards the periphery of demographic and social networks is known to increase vulnerability (Wobst 1974, 1976). Commonly, social networks are seen as a way of mitigating such increased risks; social networks, in turn, are expressed in the archaeological record through the movement of lithic and non-lithic resources over distances beyond those of day-to-day procurement (Whallon 2006). In the Hamburgian, no evidence for the maintenance of such long-distance relations is found, indicating a degree of isolation conditioned in part by the increased and increasingly northerly oriented pattern of movement. More direct indicators of mobility are difficult to elucidate archaeologically, but models of pioneering mobility that consider energetic costs and constraints do stress that a strategy of high residential mobility can be pursued (Surovell 2000; Riede 2014a). Such elevated residential mobility is traceable in the resulting settlement patterns and hierarchy.

Settlement hierarchy

In southern Scandinavia, a hierarchy in the settlement pattern of the Hamburgian is difficult to find. In fact, it is noteworthy that, in opposition to the other Late Palaeolithic techno-complexes recognised in the Danish national finds register, the Hamburgian consists of six true sites and eight spots of single finds (Figs. 6, 7 & 8). Hamburgian tools are fairly readily recognised and distinguished from the materials of later periods. Hence, this lack of a diffuse off-site signature may be (cautiously) interpreted as a generally low human presence and a limited use of the landscapes beyond known places.

The use of such known places is, in contrast, quite well established: The six currently known Hamburgian sites in Denmark are all found within just a few kilometres of each other, in the south-western (Jels 1 and 2, Slotseng, Jels 3) and south-eastern (Sølbjerg, Krogsbølle) parts of the country respectively. While tool frequencies vary at these sites, they all contain the full spectrum of materials and are of a size indicating, most likely, a single, short-term occupation by one economic/domestic unit where a range of activities were carried out (Mortensen et al. 2014; Richter 1990).

Regionality

Regionality is low in the Hamburgian beyond the two-fold division of the material into the 'classic' and Havelte phases. Lithic reduction strategies and tools design are generally highly standardised (Weber 2012). In addition, and as discussed above, the projectile point variants recognisable within the Havelte phase inventories directly link sites together but do not support a notion of regionality. Instead, they are here

Site	Type	Region
Jels 1	Assemblage	Southern Jutland
Jels 2	Assemblage	Southern Jutland
Jels 3	Assemblage	Southern Jutland
Slotseng C	Assemblage	Southern Jutland
Krogsbølle	Assemblage	Lolland
Sølbjerg 2	Assemblage	Lolland
Blå Å	Single find	Southern Jutland
Bjerlev Hede	Single find	Eastern Jutland
Bøgebjerg	Single find	Southern Jutland
Ring Mark	Single find	Eastern Jutland
Hykkelbjerg	Single find	Southern Jutland
Anesminde	Single find	Eastern Jutland
Taps	Single find	Southern Jutland
Tranegilde Tofter	Single find	Zealand

Fig. 6. Summary of known Hamburgian locales as registered in the Danish national finds database (http://www.kulturarv.dk/fundogfortidsminder/).

Abb. 6. *Zusammenstellung bekannter Fundplätze der Hamburger Kultur wie sie im nationalen Fundregister Dänemarks (http://www.kulturarv.dk/fundogfortidsminder/) erfasst sind.*

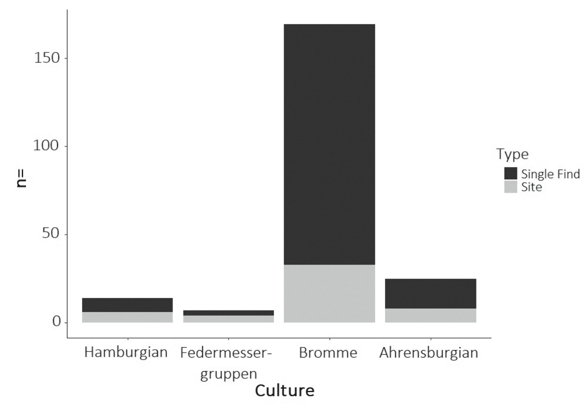

Fig. 7. The number of Late Palaeolithic finds in Denmark registered in the Danish national finds database (http://www.kulturarv.dk/fundogfortidsminder/). The composition of each Late Palaeolithic complex in terms of registered find categories is here illustrated. The comparatively low number of single finds is notable given the high diagnostic value of Hamburgian lithic artefacts.

Abb. 7. *Die Anzahl der Spätpaläolithischen Funde in Dänemark wie sie im nationalen Register verzeichnet sind (http://www.kulturarv.dk/fundogfortidsminder/). Die Funde sind nach gegrabenen Inventaren und Einzelfunden aufgeteilt. Besonders bemerkenswert ist die relativ geringe Anzahl von Einzelfunden, trotz der eher leichten Erkennung der Silexformen aus der Hamburger Kultur.*

interpreted as the signatures of individual mobility, of some individuals shifting their range north- and westwards during the later stage of the Hamburgian. It is, as the pioneer model suggests, homogeneity that characterises the Hamburgian.

Landscape knowledge

The category landscape knowledge is as critical as it is difficult to capture archaeologically. The process of moving into unknown landscapes must occur with no maps, no named landmarks nor areas memorised by storytelling, to guide you (Kelly & Todd 1988; Kelly 2003; Tolan-Smith 2003; Mevel 2013). Landscape knowledge, acquired through the process labelled landscape learning (Rockman 2003, 2009, 2012) is more often known as traditional ecological knowledge (TEK); the rich stock of knowledge and know-how traditional societies hold in relation to the affordances of their environs (e.g. Berkes et al. 2000). This knowledge vitally underpins all adaptive action in and on the environment. There is, however, little evidence in the archaeological record that allows direct inferences about this type of knowledge.

Stratigraphic position

Finally, we consider the stratigraphic position and dating of the Hamburgian more broadly. The two phases of this techno-complex overlap spatially and have hitherto been difficult to separate chronologically (Clausen 1998; Grimm and Weber 2008; Riede 2010). Excavations at Ahrenshöft LA73 in northern Germany have, however, revealed two stratigraphically separated phases of occupation (Clausen 1998). At the site, two find-concentrations, separated spatially but connected by stratigraphy, were excavated. One concentration (south) contained only projectile points of the Havelte variant in an upper layer (cultural layer I), while the northern concentration yielded both an upper (I) and a lower (II) cultural layer. In the northern concentration, projectile points of 'classic' and Havelte types co-occur. While the strict contemporaneity of the two concentrations cannot be readily established, the situation at Ahrenshöft LA73 can tentatively be seen to support the idea of a 'founder effect' process with a stepwise impoverishment (from 'classic' and Havelte to Havelte only) of the variation of projectile points, an observation that has also recently been made by Mugaj (2018). Such loss of manufacturing traditions can be seen to reflect decreasing size of the community of practice within which these Hamburgian inventories were made.

The Radiocarbon record

The set of available radiocarbon data for Hamburgian sites of both the 'classic' and the Havelte phase is plagued with two major problems. First, radiocarbon dates are sparse and second, the available dates are of very heterogeneous quality. Further complicating matters is the fact that current calibration curves show a plateau situation at around the period of the 'classic' Hamburgian and the Havelte phase. To date, two calibration curves are available, namely CalPal-2007_{HULU} and INTCAL 13, which differ significantly in a number of aspects for the period in question. Therefore, we will provide two versions of calibrated dates for comparison.

Since the last critical review ten years ago (Grimm & Weber 2008), the situation for radiocarbon dates associated with the Hamburgian has virtually not

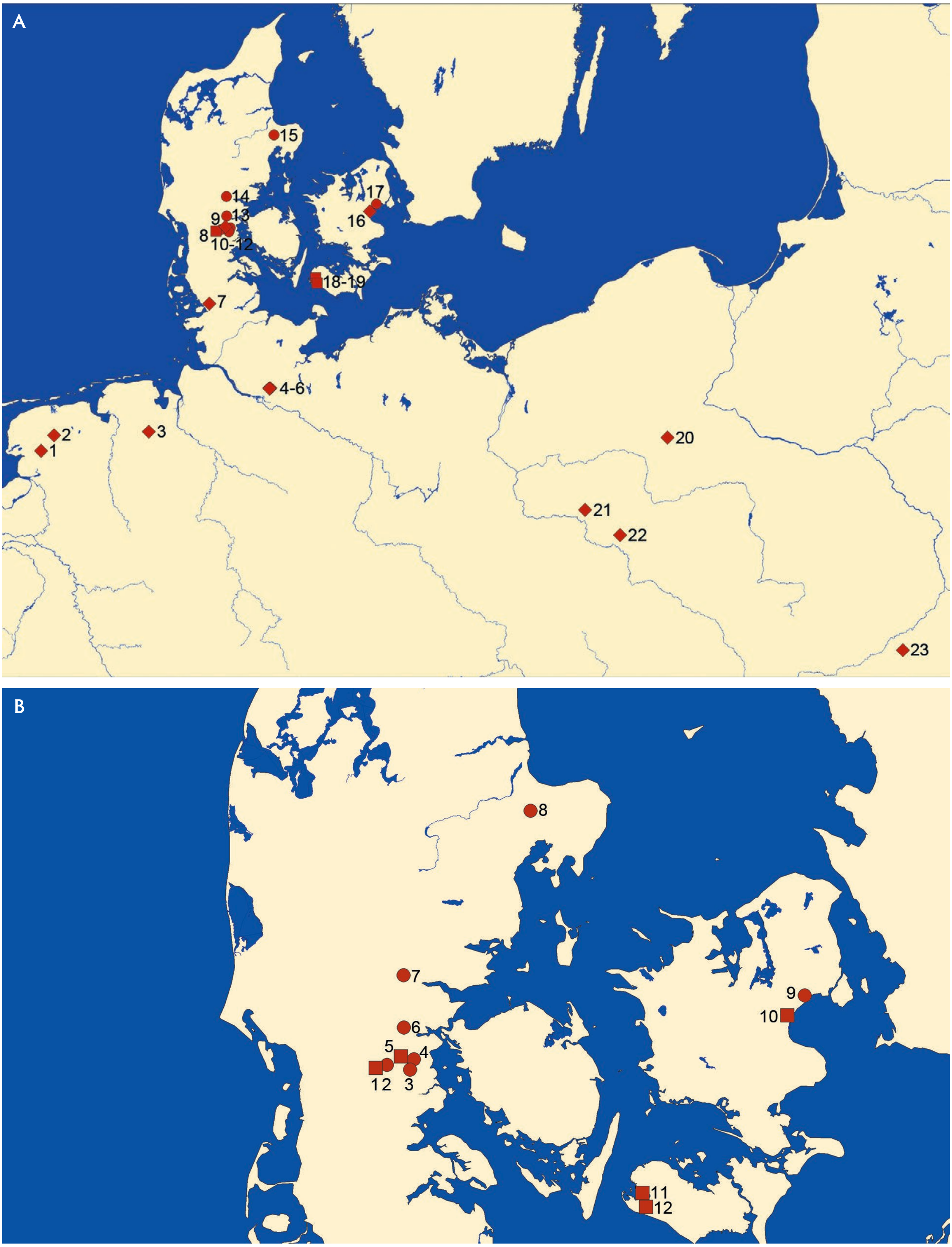

Fig. 8. A Dated sites: The sites mapped, note the concentration of sites in the south and south-east. Square: Assemblage; diamond: dated assemblage; circle: single find. 1: Oldeholtwolde, 2: Duurswoude II, 3: Querenstede, 4-6: Meiendorf, Stellmoor, Poggenwish, 7: Ahrenshöft, 8: Slotseng, 9: Solrød Strand, 10: Mirkowice, 11: Wojnowo, 12: Olbrachcice, 13: Nowy Mlyn; B Sites in Denmark. Square: Assemblage; circle: single find. Note the majority of sites are concentrated into two clusters. 1: Jels 1-3, 2: Blå Å, 3: Hykkelbjerg, 4: Taps, 5: Slotseng, 6: Bøgebjerg, 7: Anesminde, 8: Ring Mark, 9: Tranegilde Tofter, 10: Solrød Strand, 11: Krogsbølle, 12: Sølbjerg 2.

Abb. 8. *A Kartierung der Datierte Fundstellen mit 1: Oldeholtwolde, 2: Duurswoude II, 3: Querenstede, 4-6: Meiendorf, Stellmoor, Poggenwish, 7: Ahrenshöft, 8: Slotseng, 9: Solrød Strand, 10: Mirkowice, 11: Wojnowo, 12: Olbrachcice, 13: Nowy Mlyn; B Fundstellen in Dänemark Quadrate: Inventare; Kreise: Einzelfunde. Beachten Sie, dass sich die Mehrzahl der Siedlungen auf zwei Gruppierungen konzentriert. 1: Jels 1-3, 2: Blå Å, 3: Hykkelbjerg, 4: Taps, 5: Slotseng, 6: Bøgebjerg, 7: Anesminde, 8: Ring Mark, 9: Tranegilde Tofter, 10: Solrød Strand, 11: Krogsbølle, 12: Sølbjerg 2.*

changed. Tables 3 and 4 give an overview of the currently existing dates as well as an assessment of their reliability, largely following Grimm and Weber (2008). In contrast to previous studies, however, we assess the radiocarbon record under the premise that – as stated above – the sites in northern latitudes likely represent temporally closely confined activities with a short duration. Instead of assuming that every date represents a potentially independent visit of the site and thus is a meaningful signal for its occupation, and thus giving the same weight to every reliable date, we calculate weighted averages for every site and layer using CalPal (Version 2014; Weninger et al. 2014) in order to narrow down the estimate of the probable occupation event as much as possible (see appendix tables 1 and 2 for details; Weninger 1997; Weninger et al. 2011; for critique of this view see, for instance, Fiedel & Kuzmin 2007). The weighted average function in CalPal gives a probability value p, expressing the likelihood that two or more measurements relate to the same event. Whereas, for instance, the weighted average (12'100 ± 28) for two dates 12'000 ± 40 and 12'200 ± 40 has a probability 0 %, the weighted average (12'050 ± 28) for 12'000 ± 40 and 12'100 ± 40 has a probability of 7.7 %. Generally, at a value p ≥ 5 % it is permissible to consider the assumption that a group of measurements relate to a single short-term event warranted. In a second step, we compare the weighted averages of single occupations by calculating a joint weighted average for several assemblages. Again, a probability ≥ 5 % is taken as an indicator that the assumption of a quasi-contemporaneity of these assemblages (as indicated by typology, technology and site distribution) can be maintained.

We find that for the 'classic' phase of the Hamburgian, all available dates can be subsumed in one weighted average (p = 37 %), at 12'363 ± 22 uncalBP. For the Havelte phase, we find two weighted averages, one (p = 18.9 %) at 12'229 ± 18 uncalBP and another one (p = 24.4 %) at 11'719 ± 40 uncalBP. These three weighted averages cannot be aggregated further (p = 0 %). These findings allow to conclude that the Hamburgian record in the northern parts of Europe is potentially the result of only three comparably short and punctuated settlement pulses. Given that the reliability of many (if not all) radiocarbon dates of the younger Havelte signal must be considered questionable; it appears even possible that the Hamburgian phenomenon essentially represents only two northward movements of maybe a few years each (see below).

Depending on the calibration curve selected to translate this data into calendar time, two different scenarios emerge. When applying INTCAL 13 and considering a 2σ interval, the first settlement pulse probably would have occurred between 14'500 and 14'240 calBP (coinciding with the curve's plateau) and thus somewhere during the first half of the Bølling Interstadial (GI-1e), whereas the second would have taken place between 14'160 and 14'080 calBP toward the very end of the Bølling. With a probable timing between 13'580 and 13'480 calBP, the third and last settlement pulse would coincide with the GI-1c$_2$ cooling event (Fig. 9).

Still considering a 2σ interval, but applying CalPal-2007$_{HULU}$ instead, the first traces of Hamburgian hunter-gatherers seem to occur between 14'750 and 14'470 calBP, hence coinciding closely with the onset of the Bølling warming phase. In this model, the first date of the Havelte phase falls within the curve's plateau leading to an age estimate of between 14'520 and 14'100 calBP which covers virtually the entire span of GI-1e. This pulse is further supported, albeit also only broadly, by an OSL date obtained from the artefact-bearing layer at Krogsbølle of 14'300 ± 1'100 years BP. The second Havelte pulse is then, if considered reliable, estimated to have taken place between 13'700 and 13'580 calBP and thus towards the end of the early (birch-) Allerød (GI-1c$_3$), prior to the cooling phase.

The evidence for this second Havelte pulse does, however, need further discussion. Two points should here be considered. Firstly, a second pulse of Havelte colonisation, dated much later than the bulk of the remaining evidence, would either imply a rather long total timespan for Havelte presence or raise the question of where the Havelte-makers had settled in between these two pulses, a period spanning a minimum of four centuries. No relevant evidence of such nature is currently known in the archaeological record. Furthermore, such a late pulse would imply a significant overlap between the Havelte and the Federmessergruppen settlements of the area. Secondly, the problem may lie with contaminated material, making for erroneous results and this outlying colonisation pulse. All of the dates related to this young cluster derive from charcoal. Contamination of charcoal fragments with young carbon or intrusions of younger charcoal into the sampled contexts is not unlikely in open-air contexts (cf. Pettitt et al. 2003; Crombé et al. 2013). Especially material of the Oldeholtwolde site, yielding some of the youngest dates for Havelte settlement, can be argued to be contaminated and ought to be avoided when dealing with the problem of the 'classic' Hamburgian-Havelte relationship (Grimm & Weber 2008). Furthermore, assigning this site to the Havelte phase has also been questioned in regard to the projectile points (Holm 1996). It is nonetheless interesting to note that a number of dates from Havelte phase sites point to such a young Allerød-period occupation; future research – for instance, re-dating these samples or sites – must attempt to resolve this uncertainty. Yet, in our view, these young dates are unlikely to reflect a real episode of human presence.

A final matter of concern is the representativity of the radiocarbon record from Denmark. Only one site

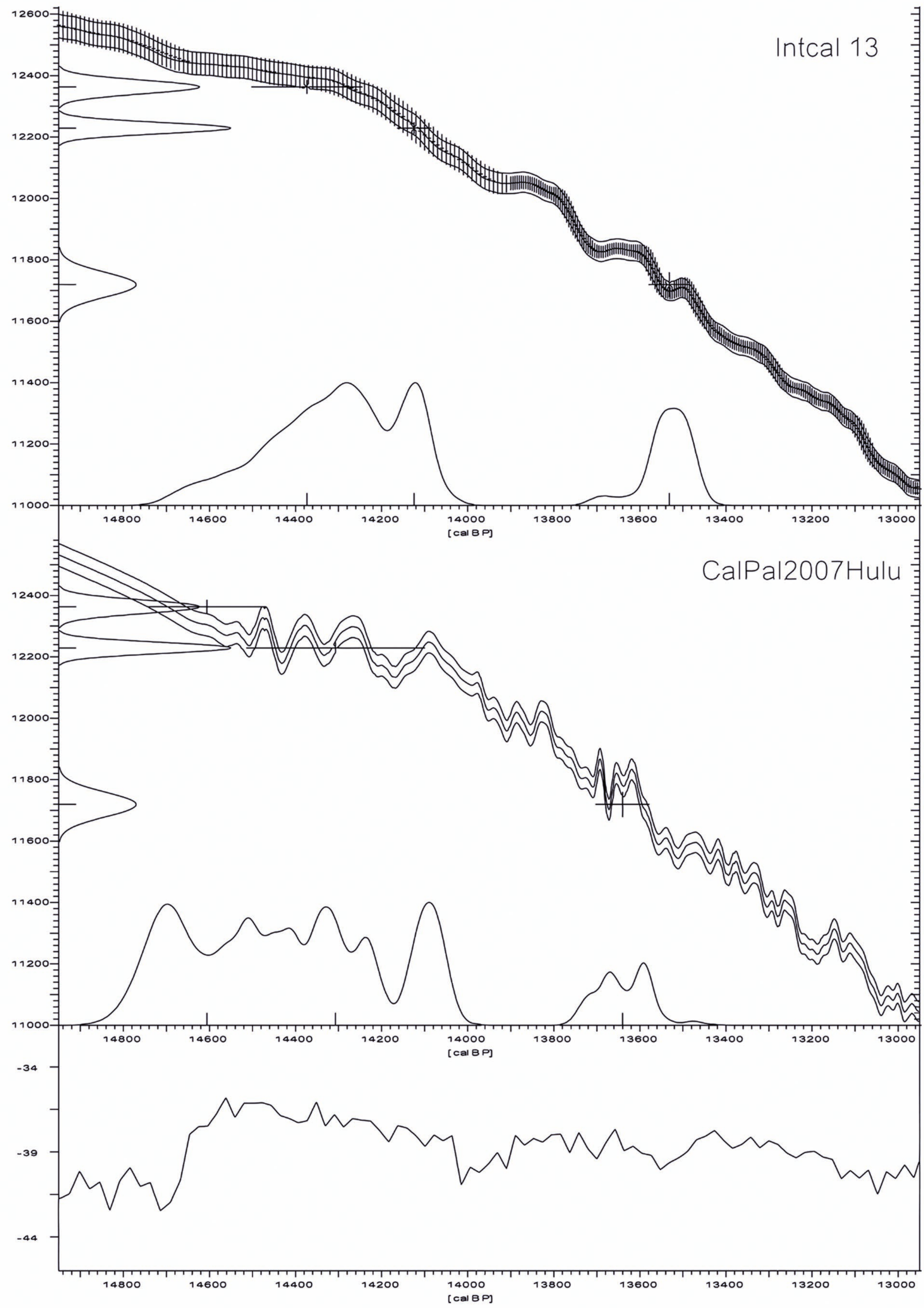

Fig. 9. Comparison between the results of a calibration of the weighted averages with INTCAL 13 and CalPal-2007$_{HULU}$. Climate model according to NGRIP GICC05 Hulu. Graphic from CalPal Version 2014 (Weninger et al. 2014).

Abb. 9. *Vergleich zwischen den Ergebnissen einer Kalibration der gewichteten Mittel mit INTCAL 13 und CalPal-2007$_{HULU}$. Klimamodell nach NGRIP GICC05 Hulu. Graphik aus CalPal Version 2014 (Weninger et al. 2014).*

is here represented, Slotseng. It can be argued that conclusions regarding the duration of the Havelte occupation in this region are difficult to draw. Yet, observations – or rather models - have to be based on the available data and Slotseng is currently the only radiocarbon-dated site from this region. That said, the number and quality of dates from Slotseng are robust and fully in line with other dates for this period. Finally, the scarcity of (dated) sites itself can also be seen to reflect the ephemeral character of this occupation.

According to the pioneering model, an initial exploratory phase should last around 600 years. Our new chronological investigation instead indicates two successive, separate and short colonisation pulses. While the Havelte phase succeeds the 'classic' Hamburgian, the Havelte phase itself is not succeeded by a later residential phase development. The Federmessergruppen settlement at the other side of the Older Dryas cold phase represents a new migration pulse into the region.

Discussion

Palaeolithic artefacts are typically understood as the residues from activities carried out by groups of people belonging to larger technological phases, cultures or techno-complexes (Gamble & Porr 2005). Dividing the Hamburgian culture into two different phases is testament to this, yet both the term phase and indeed the term culture remain poorly defined in Palaeolithic archaeology (Clark & Riel-Salvatore 2006; O'Brien et al. 2008). Palaeolithic archaeology's otherwise laudable interest in long timescales, coupled with an absence of robust models that can couple individual agency to larger-scale processes (Gravina 2004) has resulted in an interpretative bias that conceives these deep past societies as internally homogeneous – amorphous even – and where technological variation is 'explained' by the creation of new technological phases instead of individual variation within the same techno-complex. Discontinuities are often downplayed (Davey et al. 2002). The case of the Hamburgian might reflect just such a scenario, where individual signatures have been mistaken for a long-scale chronological phase, and where discontinuity has been underemphasised. The primary differences between the 'classic' Hamburgian and the Havelte phase are, as argued, the very deliberate shaping of their projectile points, geographical orientation and a very loose temporal difference. This difference in material culture, space and time may be significant for the timescales of the Havelte phase: it may have been very short indeed.

The observation on the strong similarity in projectile points within Havelte assemblages indicating individual craft signatures contrasts with the diversity of projectile points in the 'classic' Hamburgian assemblages. In the model framework proposed here, the greater variability seen in the shouldered points can be interpreted as the signature of more flintknappers. With regard to the cultural 'founder effect' it can be argued that the carriers of the 'classic' period variants have their origin in a larger (Magdalenian) source population. Processes of drift as well as selection and differential dispersal can reduce such diversity.

The observations made in relation to the Krogsbølle and Jels 3 assemblages, together with our new dating model, have significant implications for how the Hamburgian occupation of southern Scandinavia can be understood, i.e. as two (or maximum three) brief migration pulses that ultimately fail to establish a viable human presence in the region. Recognising and tracing individuals in the archaeological record through their technological and ecological decision making enables us to understand how prehistoric populations responded to changing climates. A review of the various colonising signatures of the Hamburgian indicates that heightened mobility constituted the major risk mitigation response to increasing spatio-temporal resource unpredictability (Fig. 10). And such unpredictability moves hunter-gatherer settlement systems and demography towards socio-ecological non-viability (Mandryk 1993).

Our model for the Hamburgian occupation at its northern margins differs substantially from traditional ones that focus on continuity between and contiguity with subsequent techno-complexes. Along with ecological predictions for how a given population thins out towards its socio-ecological viability margins (Fig. 11), our model argues that these foragers were increasingly moving into 'zones of disjunct distribution' and, eventually, 'zones of periodic extinction' (Gorodkov 1986; Roebroeks 2006) where the northernmost Hamburgian sites represent 'isolates' in landscapes otherwise devoid of human presence. The Hamburgian movement northwards – potentially driven by the pull factor reindeer –, the inherent instability of reindeer herds as a resource and the climatic deterioration at the end of the Bølling may have led to a very dynamic relocation of the boundaries between viable and non-viable habitation zones over timescales too short for these foragers to respond to.

Our model, we argue, is consistent not only with the archaeological evidence currently at hand, but fully in line with recent work in other Palaeolithic periods stressing the complex demographic dynamics and the ebb and flow of populations in accord with climatic and environmental changes (Maier 2017; Maier & Zimmermann 2017). What remains is to formulate ways of evaluating or even of testing this model and its alternatives. Clearly, the 'periodic extinction' model for the Hamburgian colonisation of northern Europe suggested here needs further testing. This can be done in several different complementary ways: The first of which would deal with understanding the material culture, more specifically

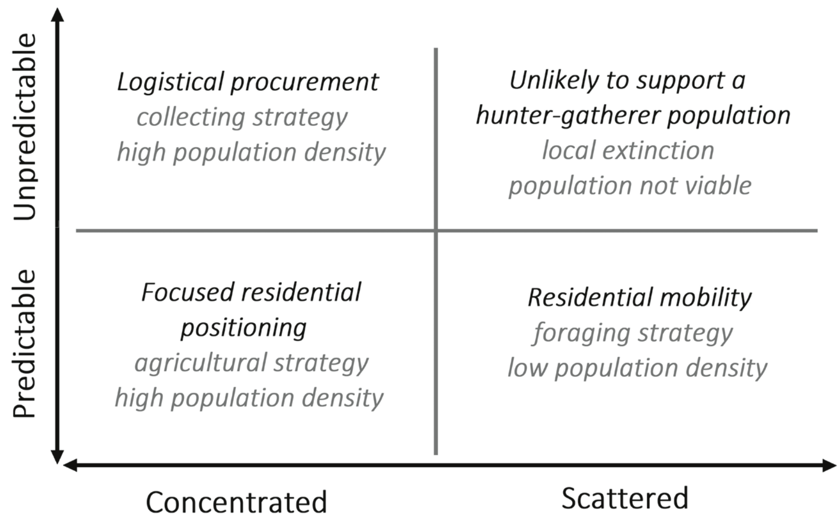

Fig. 10. A simple model of how the spatio-temporal patterns of resource availability drive hunter-gatherer mobility strategies. It is here argued that resource availability throughout the early part of the Late Glacial moved from the lower right-hand quadrant towards the upper right-hand quadrant and thereby towards an increasingly unsustainable situation. Adapted from Whallon (2006).

Abb. 10. *Ein einfaches Modell wie räumlich-zeitliche Muster von Ressourcenverfügbarkeit Mobilitätsstrategien von Jäger-Sammlern steuern. Hier wird davon ausgegangen, dass sich die Ressourcenverfügbarkeit während der frühen Phase des Spätglazials vom unteren rechten Quadranten zum oberen rechten Quadranten und somit zunehmend in Richtung weniger tragfähiger Rahmenbedingung verschoben hat. Bearbeitet nach Whallon (2006).*

the lithic inventories. A preliminary 2D geometric morphometric quantitative assessment of Hamburgian projectile points has been conducted, with some potential for capturing the shape variability of these objects (Riede & Pedersen 2018). Any such exploration of technological variability would be further strengthened by employing a mixed qualitative technological and quantitative 2D/3D geometric morphometric approach. This approach could test the potential role of individual flintknappers as agents and generators of the Hamburgian archaeological record.

A detailed re-examination of these lithic inventories would also provide a better understanding of the nature of these archaeological sites as basic economic and demographic units. Here, the Jels 3 site offers just such an opportunity. Furthermore, attempts of refitting lithic material within and between the south Scandinavian sites – as low as the success chances are – would enable us to test the hypothesis of strict contemporaneity (c.f. Scheer 1986) between these assemblages, and thereby provide direct evidence for their close temporal connection.

Lastly, it would be productive and useful to more firmly establish the environmental, demographic and network boundary conditions for demographic collapse in hunter-gatherers. Extensive datasets for recent hunter-gatherer populations make it possible to statistically link variables such as population density, subsistence strategy, climate and environment. Yet, the existing datasets share one critical flaw: they do not include the ethnographically known evidence for forager extinctions making their lower boundary estimations inaccurate. Hence, it is unknown under which environmental, demographic and social connectivity conditions hunter-gatherer populations become prone to demographic collapse. If thresholds for such a collapse risk can be identified, it will then be possible to return to the palaeoenvironmental and archaeological data available for the Hamburgian in order to assess whether this population, too, was vulnerable to such regional collapse. In sum, a judicious combination of object- and assemblage-level archaeological data together with accessible comparative ethnographic data placed in a quantitative framework would allow us to re-evaluate the overall nature of this earliest occupation of southern Scandinavia.

Conclusion

In this paper, we have presented a punctuated model for the earliest Late Palaeolithic pioneer colonisation of southern Scandinavia, with particular focus on the evidence from this period's very northern margins in present-day Denmark. If this hypothesis can be shown to be correct, this study would open up for a novel understanding of these people living in small groups and being rather vulnerable to changes in their surroundings. By using the Hamburgian as an example, an important step is taken away from seeing these cultures as amorphous long-term expressions of social traditions and towards a view of these cultures as

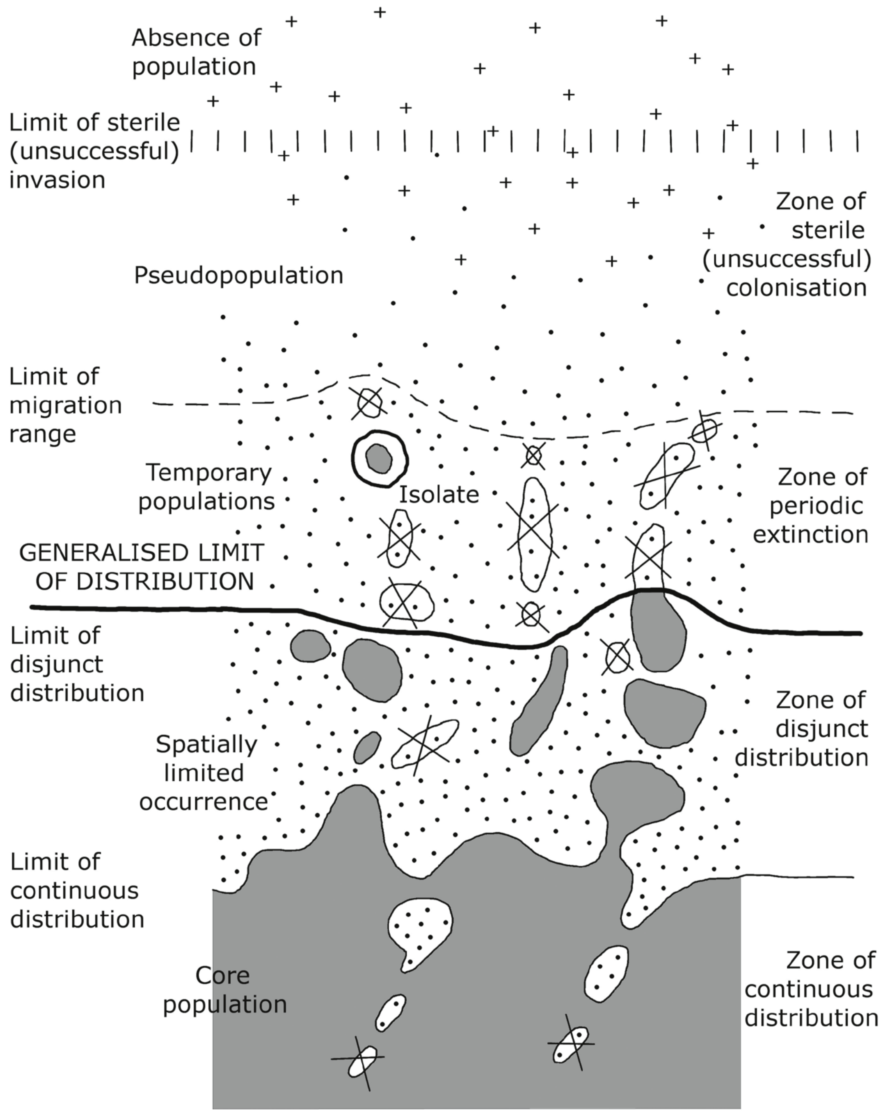

Fig. 11. A representation of how species distribute into different demographic viability zones. The Hamburgian occupation of southern Scandinavia can be argued to be operating at the limit of their migration range and hence reflect a 'pseudopopulation'. From Gorodkov (1986).

Abb. 11. *Schematische Darstellung wie Arten sich in Zonen unterschiedlicher demographischer Tragfähigkeit verteilen. Die Besiedlung von Südskandinavien durch Träger der Hamburger Kultur bewegte sich wohl an der Grenze ihres Migrationsbereiches und stellt somit eine "Pseudopopulation" dar. Aus Gorodkov (1986).*

consisting of only few people, as internally heterogeneous in the material culture expressions and as more punctuated phenomena of shorter chronological durations with more empty spaces and times in between them. With greater focus on variability rather than types of tools or technologies, judicious combinations of large-scale data-driven computational approaches with detailed qualitative artefact and site-based studies would allow capturing the internal heterogeneity of these cultures and, hence, lead to better understanding the reasons for culture change.

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A	Co	Site	Sa	Mat	Sp	Kind	Lab-Nr.	BP	Std	*P %*	wBP	Std	calBP	Std	Ex	Rf
Cl	G	Ahrenshöft LA 73, lower	1	CH	Sa/ Po	AMS	KIA-3833	12'130	60						1	1
Cl	G	Meiendorf D	4	AN, CO	Rt	CON	W-264	11'790	200						5	2
Cl	G	Meiendorf D	5	AN, CF	Rt	CON	W-281	11'870	200						6	2
Cl	G	Meiendorf D	5	AN, OF	Rt	CON	H-38/121A	12'300	300	*						2
Cl	G	Meiendorf D	5	AN, OF	Rt	CON	H-38/121B	12'300	200	*						2
Cl	G	Meiendorf D		AN, CO	Rt	CON	K-4329	12'360	110	*						3
Cl	G	Meiendorf D	4	BO	in	CON	KN-2220	12'470	250	*						4
Cl	G	Meiendorf D		CG, OF		CON	W-172	15'780	800						2,3	2
		Meiendorf D								*95.6*	12'357	86	14'540	250		
													[I]14'440	220		
Cl	P	Mirkowice 33		SE	Hr	AMS	UtC-8619	11'010	100						4	5
Cl	P	Mirkowice 33		CH	in	AMS	UtC-8618	11'820	200						4	5
Cl	P	Mirkowice 34		WO	in	CON	Gd-10892	11'850	180						4	5
Cl	P	Mirkowice 33		WO	in	CON	Gd-12124	11'950	110						4	5
Cl	P	Mirkowice 33		WO	in	CON	Gd-7851	12'160	80						4	5
Cl	P	Mirkowice 33		CH	in	AMS	UtC-8493	12'260	70						4	5
Cl	P	Mirkowice 33, conc. I		BB	in	AMS	GrA-17715	12'290	70				14'430	220		6
													[I]14'300	170		
Cl	P	Mirkowice 33		WO	in	CON	Gd-10885	12'400	230						4	5
Cl	P	Mirkowice 33		WO	in	CON	Gd-10544	12'870	190						4	5
Cl	P	Mirkowice 33		WO	in	CON	Gd-10872	13'110	200						4	5
Cl	P	Mirkowice 33		WO	in	CON	Gd-10876	16'550	320						4	5
Cl	P	Olbrachcice 8	1	CH	in	CON	LOD-111	12'685	235				15'120	390		7
													[I]14'950	460		
Cl	G	Poggenwisch D		AN	Rt	?	GrN-11262	11'250	50						4	8
Cl	G	Poggenwisch D		AN	Rt	CON	W-271	11'750	200						5	2
Cl	G	Poggenwisch D	2	AN	Rt	AMS	KIA-32925	12'265	55	*						4
Cl	G	Poggenwisch D		AN, BO	Rt	AMS	KIA-32927	12'330	55	*						4
Cl	G	Poggenwisch D	2	AN	Rt	AMS	KIA-32926	12'365	60	*						4
Cl	G	Poggenwisch D		BO, CO	Rt	CON	K-4331	12'440	115	*						3
Cl	G	Poggenwisch D		BO, CO	Rt	CON	K-4577	12'440	115	*						3
Cl	G	Poggenwisch D	6	WO	in	CON	GrN-11254	12'460	60	*						8
Cl	G	Poggenwisch D	4	BO	in	CON	KN-2754	12'470	95	*						4
Cl	G	Poggenwisch D		BO, CO	Rt	CON	K-4332	12'570	115	*						3
Cl	G	Poggenwisch D	7	ChG, OF		CON	H-32/118C	12'850	500						2,3	2
Cl	G	Poggenwisch D	8	WO	in	CON	H-136/116	12'980	370						6	2
Cl	G	Poggenwisch D		BO, OF	in	CON	H-31/67	13'050	200						5	3
Cl	G	Poggenwisch D		ChG		CON	W-93	15'150	350						2,3	3
Cl	G	Poggenwisch D	7	ChG		CON	H-32/60	15'700	350						2,3	2
Cl	G	Poggenwisch D	7	ChG		CON	H-32/118A	17'100	560						2,3	3

Appendix, Tab. 1. continued next page.

Appendix, Tab. 1. *Fortsetzung nächste Seite.*

A	Co	Site	Sa	Mat	Sp	Kind	Lab-Nr.	BP	Std	*P %*	wBP	Std	calBP	Std	Ex	Rf
										13.0	12'378	25	14'670	110		
													[I]14'420	140		
Cl	G	Stellmoor D		BO, CO	Rt	CON	K-4328	12'180	130	* °						3
Cl	G	Stellmoor D		AN, CO	Rt	CON	K-4261	12'190	125	* °						3
Cl	G	Stellmoor D		AN	Rt	CON	W-261	12'450	200	* °						2
Cl	G	Stellmoor D	4	BO, AN		CON	KN-2224	12'530	160	* °						4
Cl	G	Stellmoor D	4	BO	in	CON	KN-2223	12'590	80	*						4
										**1.9*	12'428	54	14'780	110		
													[I]14'530	190		
										°23.6	12'292	73	14'430	220		
													[I]14'310	180		
Cl	P	Wojnowo 2		CH	in	CON	Gd-2577	12'540	120				14'960	220	4	9
Cl	**P**	**Mirkowice 33**						**12'290**	**70**	*						
Cl	**G**	**Meiendorf D**						**12'357**	**86**	*						
Cl	**G**	**Poggenwisch D**						**12'378**	**25**	*						
Cl	**G**	**Stellmoor D**						**12'292**	**73**	*						
Cl	**P**	**Olbrachcice 8**						**12'685**	**235**	*						
										37.0	**12'363**	**22**	**14'610**	**140**		
													[I]14'370	**130**		

Appendix, Tab. 1. Radiocarbon dates of Hamburgian sites, 'classic' phase. A: attribution, Cl: 'classic', Hv: Havelte, in: not determined. Co: Country, D: Denmark, G: Germany, N: Netherlands, P: Poland. Sa: Sample information, 1: from hearth; 2: humanly modified; 3: with embedded stone tip; 4 bulk sample, 5: H-38/121A, H-38/121B, H-38/121C, and W-281 from same sample, 6: same sample as H-136/116, 7: H-32/118A, H-32/118C, and H-32-60 from same sample, 8: same sample as GrN-11254, 9: samples GrN-12280 and GrN-13083 possibly exchanged, 10: same sample as OxA-2562. Mat: Material, AN: Antler, BB: Burnt bone, BO: Bone, CF: Carbonate Fraction, CG: Calcalreaous Gyttja, CH: Charcoal, ChG: Chalk Gyttja, CO: Collagen, HA: Humic Acid, OF: Organic Fraction, SE: Seed, WO: Wood. Sp: Species, Hr: Hippophaë rhamnoides, in: not determined, Pi: Pinus, Po: Populus, Rt: Rangifer tarandus, Sa: Salix. P %: Probability of two or more dates being statistical identical, * dates used to calculate weighted average. Ex: reason to exclude dates, 1: stratigraphic inconsistency, 2: high standard deviation, 3: dates from soil, 4: uncertain association, 5: outlier with regard to the rest of the samples, 6: re-dating of same sample gave results more in accordance with the remaining dates, 7: samples potentially confused 8 from Allerød peat, 9 from Usselo soil. Ref: References, (1: Clausen 1998; 2: Rust 1958; 3: Fischer & Tauber 1986; 4: Grimm & Weber 2008; 5: Kabacinski & Schild 2005; 6: Lanting et al. 2002; 7: Burdukiewicz 1981; 8: Lanting & Plicht 1996; 9: Burdukiewicz 1999; 10: Hedges et al. 1992; 11: Schild & Królik 1981; 12: Fischer 1996). Dates calibrated using CalPal Version 2014 (Weninger et al. 2012). Greyed lines: Dates rejected for reasons given in row "Ex". No indication: calibration with CalPal-2007$_{HULU}$. [I] calibration with INTCAL 13. In cases where dates had to be omitted to reach probability ≥ 5 %, two weighted averages are given for comparison.

Appendix, Tab. 1. *Radiokarbondaten der Hamburger Kultur, "klassische" Phase. A: Zuordnung, Cl: 'klassisch', Hv: Havelte, in: nicht bestimmt. Co: Land, D: Dänemark, G: Deutschland, N: Niederlande, P: Polen. Sa: Informationen zur Probe, 1: aus Feuerstelle; 2: anthropogen verändert; 3: mit eingebetteter Steinspitze; 4 Sammelprobe, 5: H-38/121A, H-38/121B, H-38/121C, und W-281 von der gleichen Probe, 6: gleiche Probe wie H-136/116, 7: H-32/118A, H-32/118C, und H-32-60 von der gleichen Probe, 8: gleiche Probe wie GrN-11254, 9: Proben GrN-12280 und GrN-13083 möglicherweise vertauscht, 10: gleiche Probe wie OxA-2562. Mat: Material, AN: Geweih, BB: verbrannter Knochen, BO: Knochen, CF: Karbonatfraktion, CG: Kalkhaltige Gyttja, CH: Kohle, ChG: Kreide Gyttja, CO: Kollagen, HA: Huminsäuren, OF: organische Fraktion, SE: Samen, WO: Holz. Sp: Art, Hr: Hippophaë rhamnoides, in: nicht bestimmt, Pi: Pinus, Po: Populus, Rt: Rangifer tarandus, Sa: Salix. P %: Wahrscheinlichkeit, dass zwei oder mehr Daten statistisch identisch sind, * Daten die genutz wurden, um das gewichtete Mittel zu errechnen. Ex: Grund des Ausschlusses von Daten, 1: stratigraphische Inkonsistenz, 2: hohe Standardabweichung, 3: Daten aus Bodenproben, 4: unklare Verbindung zum Befund, 5: Ausreißer im Vergleich zu den restlichen Proben, 6: Datierung der gleichen Probe ergab eine Messung in besserer Übereinstimmung mit den restlichen Daten, 7: Proben möglicherweise vertauscht, 8 aus Allerød-Torf, 9 aus Usselo-Boden. Ref: Verweise, (1: Clausen 1998; 2: Rust 1958; 3: Fischer & Tauber 1986; 4: Grimm & Weber 2008; 5: Kabaciński & Schild 2005; 6: Lanting et al. 2002; 7: Burdukiewicz 1981; 8: Lanting & Plicht 1996; 9: Burdukiewicz 1999; 10: Hedges et al. 1992; 11: Schild & Królik 1981; 12: Fischer 1996). Daten kalibriert mit CalPal Version 2014 (Weninger et al. 2012). Ausgegraute Zeilen: Datierungen verworfen aus in Spalte „Ex" angegebenen Gründen. Kein Vermerk: Kalibration mit CalPal-2007$_{HULU}$. [I] Kalibration mit INTCAL 13. In Fällen, in denen Daten ausgelassen werden mussten um eine Wahrscheinlichkeit ≥ 5 % zu erreichen, werden zwei gewichtete Mittel zum Vergleich angegeben.*

A	Co	Site	Sa	Mat	Sp	Kind	Lab-Nr.	BP	Std	*p %*	wBP	Std	calBP	Std	Ex	Rf
Hv	G	Ahrenshöft LA 58 D	1	CH	in	AMS	AAR-2784	12'030	60				13'920	90		1
													[I]13'890	90		
Hv	G	Ahrenshöft LA 73, upper		CH, HA	Sa/ Po	AMS	KIA-3606(a)	11'750	60				13'660	70		1
													[I]13'590	90		
Hv	G	Ahrenshöft LA 73, upper		CH	Pi	AMS	KIA-3605	12'200	60				14'290	220		1
													[I]14'090	80		
Hv	G	Ahrenshöft LA 73, upper		CH	Sa/ Po	AMS	KIA-3606	12'550	1170						2	1
Hv	N	Duurswoude II		CH	in	CON	GrN-1565	11'090	90						4	8
Hv	N	Oldeholtwolde	9	CH	Sa	CON	GrN-12280	11'080	280						7	8
Hv	N	Oldeholtwolde		CH	Pi	CON	OxA-2560	11'300	110						9	10
Hv	N	Oldeholtwolde		CH	in	CON	GrN-11264	11'340	100						8	8
Hv	N	Oldeholtwolde	1	CH	SA	AMS	OxA-2559	11'470	110	*						10
Hv	N	Oldeholtwolde	1	CH	Sa	CON	GrN-10274	11'540	270	*						8
Hv	N	Oldeholtwolde	9	CH	Sa	CON	GrN-13083	11'600	250						7	8
Hv	N	Oldeholtwolde	1	CH	SA	AMS	OxA-2561	11'680	120	*						10
Hv	N	Oldeholtwolde	1	CH	SA	AMS	OxA-2558	11'810	110	*						10
										17.1	11'646	63	13'520	80		
													[I]13'470	70		
Hv	D	Slotseng	2	AN	Rt	AMS	AAR-8161	12'065	80	*						4
Hv	D	Slotseng		BO	Rt	AMS	AAR-8158	12'165	55	* °						4
Hv	D	Slotseng		BO	Rt	AMS	AAR-8164	12'190	50	* °						4
Hv	D	Slotseng		BO	Rt	AMS	AAR-8163	12'205	65	* °						4
Hv	D	Slotseng		AN	Rt	AMS	AAR-8162	12'220	100	* °						4
Hv	D	Slotseng	3	BO	Rt	AMS	AAR-8160	12'240	50	* °						4
Hv	D	Slotseng		BO	Rt	AMS	AAR-8165	12'290	75	* °						4
Hv	D	Slotseng	2	AN	Rt	AMS	AAR-8157	12'299	41	* °						4
Hv	D	Slotseng	2	AN	Rt	AMS	AAR-8159	12'410	70	* °						4
Hv	D	Slotseng		AN, BO	Rt	AMS	AAR-906	12'520	190	* °						4
										**2.9*	12'242	20	14'330	210		
													[I]14'140	40		
										° 10	12'253	20	14'350	210		
													[I]14'150	40		
in	P	Nowy Mlyn St.Ia/23		CH	in	CON	Bln-2037	11'970	125	*						11
in	P	Nowy Mlyn St.Ia/23		Ch	in	CON	Gd-724	11'940	300	*						11
in	P	Nowy Mlyn St.Ia/23		CH	in	CON	Gd-725	12'290	210	*						11
										39,8	12'041	101	14'030	190		
													[I]13'900	120		

Appendix, Tab. 2. continued next page.

Appendix, Tab. 2. *Fortsetzung nächste Seite.*

A	Co	Site	Sa	Mat	Sp	Kind	Lab-Nr.	BP	Std	*p %*	wBP	Std	calBP	Std	Ex	Rf
in	G	Querenstede	10	CH	in	CON	KN-2707	12'650	320						2;6	8
in	G	Querenstede		CH, HA	in	AMS	OxA-2562	11'840	110				13'740	120		10
													[I]13'670	120		
in	D	Solrød Strand	2	AN	Rt	CON	AAR-1036	12'140	110				14'230	260		12
													[I]14'010	160		
Hv1	**G**	**Ahrenshöft LA 58 D**						**12'030**	**60**	*						
Hv1	**P**	**Nowy Mlyn St. Ia/23**						**12'041**	**101**	* °						
Hv1	**D**	**Solrød Strand**						**12'140**	**110**	* °						
Hv1	**G**	**Ahrenshöft LA 73, upper**						**12'200**	**60**	* °						
Hv1	**D**	**Slotseng**						**12'242**	**20**	* °						
										***0.5**	**12'212**	**18**	**14'270**	**190**		
													[I]14'110	**40**		
										°18.9	**12'229**	**18**	**14'310**	**210**		
													[I]14'120	**40**		
Hv2	**N**	**Oldeholt-wolde**						**11'646**	**63**	*						
Hv2	**G**	**Ahrenshöft LA 73, upper**						**11'750**	**60**	*						
Hv2	**G**	**Querenstede**						**11'840**	**110**	*						
										24.4	**11'719**	**40**	**13'640**	**60**		
													[I]13'530	**50**		

Appendix, Tab. 2. Radiocarbon dates of Hamburgian sites, Havelte phase. Dates younger 11'000 BP/13'000 calBP not shown. For Nowy Mlyn, Querenstede, and Solrød Strand, the archaeological attribution the Havelte Phase is uncertain and an attribution is based on the radiocarbon dates. For abbreviations see Table 3.

Appendix, Tab. 2. *Radiokarbondaten der Hamburger Kultur, Havelte Phase. Daten jünger als 11'000 BP/13'000 calBP nicht enthalten. Für Nowy Mlyn, Querenstede, und Solrød Strand ist die archäologische Zuordnung zur Havelte Phase unsicher und erfolgt aufgrund der Radiokarbondaten. Für Abkürzungen siehe Tabelle 3.*

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